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The Development of Two-Dimensional Geometry Flashcard Media in Stimulating Children's Cognition

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Abstract

Early childhood education frequently encounters obstacles in developing geometric understanding due to the abstract nature of shapes and a lack of contextual visual aids, as observed at Harapan Mulia Kindergarten. This study aims to develop innovative two-dimensional geometry flashcards and rigorously evaluate their feasibility, practicality, and effectiveness in stimulating children's cognitive abilities. Using a Research and Development (R&D) approach with the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation), the study involved 15 children from Group B. Data were collected through expert validation instruments, observations, and geometry learning tests, which were then analyzed using a paired sample t-test to measure cognitive shifts. The result showed that expert validation from material and media specialists achieved a 92% "highly feasible" rating. Product trials with children yielded an 89% practicality score, falling into the "highly practical" category. Statistical analysis revealed a significant cognitive improvement, with mean scores rising drastically from 57.46 to 89.20 (p =.000 < 0.05). This success is attributed to the integration of the Concrete–Pictorial–Abstract (CPA) approach and high-contrast visual designs that enhance memory retention. The findings demonstrate that contextually designed flashcards serve as a vital instructional alternative for teachers to accelerate mathematical conceptualization and active engagement in early learners, providing a scalable model for foundational geometry education.

Keywords: Cognitive Development, Geometry Flashcards, Two-Dimensional Media

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Abstrak

Pendidikan anak usia dini sering menghadapi kendala dalam mengembangkan pemahaman geometri akibat sifat abstrak dari bentuk-bentuk geometri serta kurangnya alat bantu visual yang kontekstual, sebagaimana diamati di Taman Kanak-Kanak Harapan Mulia. Penelitian ini bertujuan untuk mengembangkan flashcard geometri dua dimensi yang inovatif serta mengevaluasi secara mendalam kelayakan, kepraktisan, dan keefektifannya dalam merangsang kemampuan kognitif anak-anak. Dengan menggunakan pendekatan Penelitian dan Pengembangan (R&D) berdasarkan model ADDIE (Analisis, Desain, Pengembangan, Implementasi, dan Evaluasi), penelitian ini melibatkan 15 anak dari Kelompok B. Data dikumpulkan melalui instrumen validasi ahli, observasi, dan tes pembelajaran geometri, yang kemudian dianalisis menggunakan uji-t sampel berpasangan untuk mengukur perubahan kognitif. Hasilnya menunjukkan bahwa validasi ahli dari spesialis materi dan media mencapai peringkat "sangat layak" sebesar 92%. Uji coba produk dengan anak-anak menghasilkan skor kepraktisan sebesar 89%, masuk dalam kategori "sangat praktis". Analisis statistik menunjukkan peningkatan kognitif yang signifikan, dengan skor rata-rata naik drastis dari 57,46 menjadi 89,20 (p = 0,00 < 0,05). Keberhasilan ini dikaitkan dengan integrasi pendekatan Konkret–Piktural–Abstrak (CPA) dan desain visual kontras tinggi yang meningkatkan retensi memori. Temuan ini menunjukkan bahwa flashcard yang dirancang secara kontekstual berfungsi sebagai alternatif instruksional yang vital bagi guru untuk mempercepat konseptualisasi matematika dan keterlibatan aktif pada siswa usia dini,

Kata Kunci: Perkembangan Kognitif, Kartu Geometri, Media Dua Dimensi

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INTRODUCTION

Education today faces great challenges due to globalization, so various efforts are needed to help students achieve a decent life in their own country or abroad. Children's education is first shaped by the family environment, especially by both parents. The next process, when the child will interact with the second environment, is an educational institution. Education has a very important role in developing individual skills and behavior in a more positive direction. (Gagaramusu et al., 2025).

Early childhood education plays a very important role in the Golden Age; therefore, teachers and parents of early childhood children are expected to master the basics of development, as every child's developmental process influences subsequent development (Kiptiah, 2023). The quality of education is important to ensure that education runs as expected, has a positive impact on change, and builds students' knowledge and skills (Zuama, 2024).

Early childhood education plays a crucial role in a child's development and growth. Children experience rapid brain development. Research conducted in the United States indicates that early childhood education, linked to later achievement, is an area of interest for intervention (Lind et al., 2024). Early childhood has various potentials that must be developed. Although children generally follow the same developmental patterns, the rhythm of development will differ from one child to another because, in essence, children are individuals (Ardiana, 2021).

In an effort to support the education of these children, various measures are taken to ensure they receive the best possible education. Its function is to cultivate abilities and form character, as well as to build a useful civilization that educates the nation's life. The goal is to develop students' potential to become human beings who believe in and fear God Almighty, have noble character, are healthy, knowledgeable, capable, independent and become democratic and responsible citizens.

To ensure a successful transition to elementary education, children must develop holistically across domains such as cognitive, linguistic, physical-motor, socio-emotional, moral-religious, and artistic skills. Among these, cognitive development serves as a critical foundation for intelligence and problem-solving abilities in early childhood. Cognitive development is a particularly important area to nurture and stimulate in children from an early age.

Cognitive development is the ability to solve problems in the thinking process, namely the individual's ability to connect, assess, and consider a later or future event. The cognitive process is related to the level of intelligence that marks a person with various interests, especially those aimed at learning ideas. The development of basic potential in early childhood includes the formation of children's personality and character (Fahruddin & Astini, 2018). Cognitive development is the basis for the development of intelligence in early childhood (Fauziddin & Mufarizuddin, 2018; Nurhayati, 2020).

Based on survey results and initial observations, followed by interviews with the school principal and classroom teachers, several issues were identified. This was evident during classroom instruction, when the teacher explained various geometric shapes. Most of the students were unfamiliar with and did not understand the geometric shapes presented by the teacher. Many students incorrectly or inaccurately identified and described the geometric shapes the teacher displayed in class.

Based on the findings and analysis of these issues, it is evident that a structured approach is needed to stimulate children's cognitive abilities in Group B at Harapan Mulia Kindergarten. If this issue is not promptly addressed with an appropriate solution or approach, it will be challenging to stimulate children’s cognitive development from an early age. After analyzing the needs for the various learning materials available in the classroom and at the school, the researcher chose to create engaging flashcards for the children.

The selection of flashcards as a medium to stimulate the ability to recognize geometric shapes is based on their attractiveness in terms of color and images, as well as their ability to represent concrete objects. According to Angreany and Saud (2017), flashcards are one of the learning media in the form of graphics,

small picture cards. Usually made using photos, symbols, or images attached to the front side, and on the back side, a description in the form of words or sentences from the flashcard image. In addition, flashcards are learning media in the form of images of a certain size, such as squares or rectangles.

The purpose of using flashcard media is to train children's cognitive memory about geometry concepts. Flashcards can be used to introduce both number and geometry concepts by using images as symbols. Flashcard learning media can help remind or direct children to something related to the image. Flashcard media is a learning medium that can stimulate children's cognitive abilities (Evianti & Atika, 2021; Utami, 2023).

Flashcards are designed as picture cards that display simple visual information, making it easier for children to grasp basic concepts. Visual media is the most commonly used medium in the learning process. This is because students prefer images, especially when they are colorful and presented according to the students' needs and abilities (Wahyuni, 2020). This medium is highly relevant to the characteristics of early childhood, who tend to learn through visuals and concrete experiences (Syamsiyah & Ma'rifatulloh, 2023).

The implementation of innovative learning media has become a necessity for addressing cognitive stagnation in children, particularly in subjects that require concrete visualization, such as geometry. In this context, various studies have explored the potential of flashcards as an effective cognitive stimulation instrument across various aspects of early childhood development.

The effectiveness of flashcards in enhancing children's cognitive abilities has been widely validated by previous studies that emphasize the power of simple visualization. Specifically, this medium has proven effective in facilitating the recognition of symbolic concepts, ranging from number recognition through marble card variations (Roziana & Khasanah, 2022) to the stimulation of early counting skills (Wati, 2021).

Beyond the domain of numeracy, the use of flashcards has also demonstrated significant success in literacy, particularly in accelerating the recognition of vowel and consonant letters while improving children's memory of letter structures (Levi et al., 2023). Collectively, these findings from Israwati et al. (2022), Rahmasari et al. (2022), and others confirm that flashcards are not merely teaching aids but strategic media that can stimulate brain activity and memory by presenting focused visual information. However, while the existing literature highlights success in numeracy and literacy, there remains a gap in the use of flashcards integrated with real-life contexts for two-dimensional geometry. This gap serves as the primary focus of this study.

Previous studies on flashcards have tended to focus solely on abstract images and text, primarily within the domains of numeracy and literacy (Israwati et al., 2022; Levi et al., 2023; Roziana & Khasanah, 2022). However, a significant gap remains in the use of flashcards specifically integrated with real-life contexts for two-dimensional geometry. In contrast, the media developed in this study links geometric shapes to objects in the students' surroundings; for example, associating a rectangle with a door.

Based on this background, this study aims to develop environmental context-based two-dimensional geometry flashcards to improve the cognitive abilities of Group B children at Harapan Mulia Kindergarten. By developing these context-based flashcards, this study is expected to provide a highly effective and practical medium for significantly enhancing children's cognitive mastery of two-dimensional geometric concepts.

METHODS

This study used the Research and Development (R&D) method, specifically designed to develop and validate educational products. Unlike basic research that merely offers suggestions, this approach is oriented toward creating functional tools that can be directly implemented in learning environments. The development of flashcard media to stimulate children's cognitive abilities is guided by the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation).

The ADDIE framework is selected for its rational, comprehensive, and systematic nature, making it highly effective for developing a range of instructional materials,

including learning media and teaching strategies. This model provides a structured pathway to navigate the complexities of intentional learning environments, ensuring that every phase—from initial needs analysis to final product evaluation—contributes to the creation of a valid and effective educational tool (Rohaeni, 2020). By following these systematic stages, the research ensures that the resulting flashcards are not only theoretically sound but also practically suitable for school requirements

The following is an image of the ADDIE development stages.

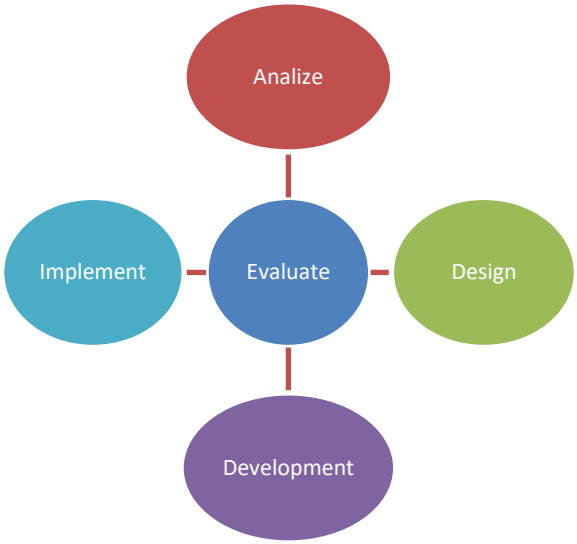

Figure 1. Research Development Model

In accordance with the ADDIE description, the author will explain the stages of this development research plan, as follows:

Analyze

This phase involves a comprehensive needs assessment to identify specific cognitive challenges in geometry recognition among students in Group B at Harapan Mulia Kindergarten. Data collection is conducted through semi-structured interviews with teachers and direct observation of existing school facilities. These activities aim to establish a baseline for learning objectives and determine the necessary specifications for a more engaging and effective instructional medium.

Design

The design phase serves as a procedural framework for translating analysis results into a product blueprint prior to physical development. This stage involves several technical planning steps:

1. Structural Planning: Establishing specific dimensions for the flashcards, set at 17.5 cm x 17.5 cm, intended to facilitate children's visual focus on single-object imagery.
2. Material Standardization: Selecting durable material specifications, including 260 gsm art paper and thick blush-white paper, to ensure the media's longevity for repeated classroom use.
3. Visual Formatting: Creating a design protocol that emphasizes high-contrast colors and clear symbols to stimulate cognitive memory regarding geometry concepts.
4. Curriculum Mapping: Identifying and selecting two-dimensional shapes, such as trapezoids, rhombuses, and pentagons, to be integrated into the media based on early childhood learning objectives.

Development

The development stage involves translating the finalized design into a physical prototype and ensuring its pedagogical validity.

1. Product manufacturing. This stage is the product printing stage, based on the product design that was designed at the design stage. All components that have been designed and prepared are assembled into a single unitary component for flashcard media products.
2. Validation Process. Design validation and trial use of media in this study through the assessment stage, involving media and subject matter experts to evaluate the design and material accuracy

The results of this stage are in the form of criticism, suggestions, and comments that can serve as a basis for stage one revisions to the media that have been developed. The product will be revised based on the validators' comments and suggestions. After the initial stage revision, the product is resubmitted to media experts, material experts and practitioners for final-stage validation. After it

is declared feasible to be tested, the next step is to test the media on users.

The feasibility of the geometry flashcards is determined through a quantitative analysis of validation data gathered from material and media experts. This percentage-based assessment is calculated by comparing the obtained scores against the maximum possible score to establish the product's validity level.

$$P = \frac{F}{N} x100\%$$

Description:
P = Feasibility/validity percentage
F = Score is obtained
N = Maximum score

The evaluation instruments for media and subject matter experts are structured based on specific performance indicators as detailed in Table 1 and Table 2.

Table 1. Media Expert Instruments

No.	Indicators
1	The title on the flashcard reflects the product's content: introducing geometric concepts.
2	Accuracy of the dimensions on the flashcard cover
3	The flashcards are made of 260 gsm art paper and thick blush-white paper.
4	Suitability of the materials selected for the flashcards
5	Flashcards encourage children to actively engage in activities that help them recognize geometric shapes.
6	Flashcards can stimulate children's cognitive abilities in identifying geometric shapes.
7	Flashcards can stimulate children's cognitive development by helping them group geometric shapes.

Table 2. Subject Matter Expert Instrument

No.	Indicators
1	The alignment of flashcard content with learning objectives and aspects of cognitive development in early childhood.
2	Children can easily understand each distinct image from start to finish.
3	Stimulates cognitive skills (identifying geometric shapes).
4	Stimulates cognitive skills (grouping geometric shapes).
5	Stimulates cognitive skills (recognizing geometric shape patterns).

To evaluate product feasibility, validation sheets are utilized to assess design, visual clarity, color suitability, material accuracy, and cognitive stimulation capabilities as detailed in Tables 1 and 2. This testing procedure follows the systematic ADDIE development model to ensure media consistency. Furthermore, the calculated feasibility percentages are interpreted using the expert validation criteria.

Table 3. Criteria of Expert Validation

No.	Percentage	Criteria
1.	85%-100%	Very feasible
2.	70%-84%	Feasible
3.	55%-69%	Less feasible
4.	40%-54%	Not feasible
5.	25%-39%	Very not feasible

Implementation

The Implementation phase involves the practical application of the geometry flashcards within the actual learning environment at Harapan Mulia Kindergarten. During this stage, the media is integrated into the classroom routine for Group B students, with flashcards used twice a week to facilitate understanding of two-dimensional geometric concepts. This phase serves as the primary data collection period to observe children's interactions with the media and to assess the product's practicality in a real-world instructional setting.

Evaluation

The evaluation phase is conducted to measure the impact of the developed media against the initial learning objectives. This stage involves a comprehensive analysis of the product's validity and practicality, based on user feedback and expert assessments. Furthermore, an effectiveness test is performed to evaluate the shift in children's cognitive abilities following the implementation period. This systematic evaluation ensures that every phase of the ADDIE model contributes to the final refinement of the media, resulting in a validated educational tool that is both pedagogically sound and instructionally effective.

RESULTS AND DISCUSSION

The development process resulted in a context-based two-dimensional geometry flashcard set designed to stimulate children's cognitive abilities. The development followed the systematic ADDIE phases with the following results.

The assessment identified that a critical lack of learning facilities at Harapan Mulia Kindergarten directly impacts students' lack of understanding of geometry concepts. These findings established the need for a visual medium that connects abstract geometric figures with familiar objects in the children's environment.

A conceptual framework was developed over approximately two months (March to May 2025) to translate identified needs into physical product specifications. The technical design focused on optimizing the child's visual focus, visual range, and motor coordination by selecting a specific size of 17.5 cm x 17.5 cm. The design process involved curating high-contrast color schemes and clear imagery to effectively stimulate cognitive memory regarding shapes such as trapezoids, parallelograms, circles, rhombuses, rectangles, kites, pentagons, triangles, and ovals.

In the development phase, the media was manufactured into ready-to-use flashcards using 260 gsm art paper and thick blush-white paper for maximum durability. All designed components were assembled into a unitary product, which was then iteratively revised based on feedback until an effective learning tool was achieved. The final product consists of a cover page and ten detailed shape cards (parallelogram, pentagon, trapezoid, triangle, square, circle, rectangle, oval, kite, and rhombus). This complete geometry set, as shown in Figure 1, was then subjected to expert validation to ensure its pedagogical and technical quality.

Figure 2. Two-Dimensional Geometry Flashcard Media Design

The scope of the material in this development aligns with the curriculum at Harapan Mulia Kindergarten in Birobuli Utara, Palu City, specifically under the theme "My Environment" and the subtopic "My House." The media targets three specific cognitive indicators as detailed in Table 4.

Table 4. Targeted Cognitive Aspects of Children

No.	Indicators
1	Mentioning Geometric Shapes
2	Classifying Geometric Shapes
3	Recognizing Geometric Shape Drawing Patterns

The developed flashcards underwent a rigorous validation process involving two expert validators (Media and Subject Matter experts) from relevant academic backgrounds. Validator I (Media Expert) assigned a score of 89%, noting that the media was engaging and well-designed, with a specific recommendation to adjust the color of the circle image. Validator II (Subject Matter Expert) provided a score of 95%, concluding that the media was feasible for classroom use without further revision.

The combined average score from both validators was calculated as follows:

$$P = \frac{89 + 95}{200} \times 100$$

$$P = 92\%$$

Referring to the interpretation criteria in Table 3, the final score of 92% categorizes the geometry flashcards as "Very Feasible." Following these results, the researchers implemented the suggested revisions, specifically adjusting the circle illustration's color and incorporating a preface, to ensure the final product met the highest instructional standards.

Following the expert validation and subsequent revisions, a small-scale product trial was conducted with the children in Group B. The trial focused on the media's practicality and its immediate impact on the children's learning behavior. The product trial yielded a feasibility score of 89%, placing the flashcards in the "Very Feasible" category for classroom implementation.

The qualitative observations during this trial indicated significant behavioral shifts. The use of flashcards led to increased attention, enthusiasm, and active engagement. Children appeared more focused, demonstrated quicker shape recognition, and showed greater confidence when identifying geometric concepts. This positive response stems from the media's engaging visuals, which stimulate curiosity and encourage direct involvement.

Furthermore, the strategic use of color, refined during the validation phase, proved essential for visual discrimination. The high-contrast colors served as critical visual cues, reinforcing memory and accelerating the recognition process. By helping children distinguish between different geometric properties more clearly, the visual design directly boosted learning effectiveness and enhanced the overall instructional appeal of the content.

To evaluate the effectiveness of the developed flashcards, a field trial was conducted with 15 children in Group B. The results of the pre-test and post-test were analyzed using a Paired Samples T-Test, as summarized in the following tables.

Table 5. Descriptive Statistic

	Mean	N	Std. Deviation	Std. Error Mean
Pres-Test	57.466	15	2.2949	.5925
Post-Test	89.200	15	1.6124	.4163

Table 6. Paired Samples T-Test Statistics

	Pair Differences					
	Mean	Std. Dev.	Std. Error Mean	t	df	Sig. (2-tailed)
Pair 1	-31.733	2.344	0.605	-52.429	14	.000

The improvement in cognitive scores from an average of 57.46 to 89.20 (see Table 5) can be explained by the concrete–pictorial–abstract (CPA) learning theory. In the concrete stage, children understand concepts through objects or real-world representations. In the pictorial stage, geometry flashcards serve as a visual medium that helps children clearly see the shapes and properties of geometric figures. Furthermore, in the abstract stage, children can understand concepts without media support,

such as independently identifying the properties of geometric figures.

Thus, it can be concluded that the flashcard learning media developed can stimulate early childhood cognitive development. This can be seen in the results of the t-test on the post-test of cognitive abilities in Table 6, which show a p-value (Sig. 2-tailed) of .000 (< 0.05). H_0 is rejected, and H_a is accepted, confirming that the use of geometry flashcards significantly improves children's cognitive abilities.

Discussion

The results of this study demonstrate that the development of context-based geometry flashcards significantly enhances children's cognitive abilities in Group B. The empirical evidence from the Paired Samples T-Test, showing a mean increase from 57.47 to 89.20 ($p < 0.05$), aligns with Kurniawati's (2022) findings, which showed that flashcards significantly influence symbolic thinking and early literacy. Furthermore, the high feasibility score of 92% in this study aligns with the research of Tima et al. (2023) and Woa et al. (2022), which used the ADDIE model to develop "highly valid" instructional media for cognitive stimulation.

While studies by Azhima et al. (2021) and Safariyah et al. (2023) focused primarily on numeracy and simple operations, this research confirms that the effectiveness of flashcards extends beyond mathematics into geometric spatial recognition. This is consistent with Listy and Zumrotun (2025), who argued that well-designed visual media not only improve scores but also boost learning motivation and active participation.

The primary strengths and novelty of this study lie in integrating environmental contexts into the design of two-dimensional geometry flashcards. Unlike previous studies that focused on digital or application-based flashcards to explore student responses (Hidayati et al., 2025) or those emphasizing creative thinking skills through "Flat Facts" media in elementary settings (Fadhilah & Kusuma, 2025), this study specifically addresses the cognitive needs of early childhood through tangible, contextually-linked media. While Umyati & Rocmah (2025) demonstrated the effectiveness of simple geometric shape media for 4-5 year olds, this research uniquely bridges the gap between abstract geometric theory and the child's immediate surroundings—such as associating a rectangle with the frame of a house door—consistent with the principles of Realistic Mathematics Education (RME) (Gravemeijer, 2020).

Furthermore, while literature reviews by Riadoh et al. (2025) confirm the general utility of flashcards for early mathematics, this study elevates their role by simultaneously activating multiple cognitive dimensions, including analytical thinking and classification through real-world modeling (Gravemeijer, 2020). By positioning children as active participants who connect visual symbols with familiar objects, the learning process becomes more meaningful and less abstract than conventional rote-memorization methods.

The significant improvement in cognitive mastery observed in this study is theoretically underpinned by the Concrete–Pictorial–Abstract (CPA) framework. The flashcards act as a critical pictorial bridge, facilitating the transition from physical manipulation to mental representation. By utilizing high-contrast colors and familiar contextual cues, the media reduces the cognitive load during visual discrimination. This aligns with the findings of Umyati and Rocmah (2025), which demonstrate that concrete, context-related geometric shape media effectively stimulate cognitive growth and logical thinking in children aged 4-5 years. Furthermore, Riadoh et al. (2025) emphasize that clear visualizations on flashcards make it easier for children to understand basic geometric concepts and number quantities. This systematic transition ensures that children do not merely engage in rote memorization but develop a deep conceptual understanding of geometric properties.

Despite the significant results, this study has limitations in scale, involving only 15 children, and caution is warranted when generalizing the findings to broader populations. Moreover, the current study remains focused on conventional printed media.

Future researchers are encouraged to bridge the gap between physical media and digital technology. The integration of

Augmented Reality (AR) or the development of Android-based applications, as explored by Hidayati et al. (2025), represents a compelling direction to enhance interactive student responses. Furthermore, future media development should be directed toward stimulating more complex skills, such as critical thinking. As demonstrated by the Flash Card Palindrome (FCPM) developed by Harianja et al. (2025), instructional media must be designed not only for visual recognition but also to support curricula that demand critical thinking skills in the globalization era. Continuous validation encompassing instructional design aspects, as suggested by Woa et al. (2022), remains an absolute requirement for future media development to ensure pedagogical and technical excellence.

In conclusion, the environmental context-based geometry flashcards developed in this study are conceptually sound and practically transformative. This research provides a tangible contribution to early childhood education by offering a validated, high-impact instructional tool. The impact extends to independent use by parents at home, confirming that attractive visual displays on flashcards significantly enhance children's memory retention and understanding. Overall, this study demonstrates that an innovative design that combines contextual relevance and cognitive stimulation is a superior strategy for fostering 21st-century foundational skills in early learners, creating an active and meaningful learning environment.

CONCLUSION

The development of environmental context-based geometry flashcards has been proven to be both conceptually sound and practically effective in stimulating early childhood cognitive development. Following the systematic ADDIE model, the product achieved a high feasibility score for instructional use. This feasibility is supported by the media's ability to simplify abstract geometric concepts into tangible, context-related visual aids that align with the cognitive characteristics of children in Group B.

Empirical evidence from field trials confirms the media’s effectiveness, as demonstrated by a significant increase in children's average cognitive scores. The Paired Samples T-test resulted in a significance value of 0.000 ($p < 0.05$), indicating that the contextually relevant design of the flashcards successfully fosters logical reasoning and classification skills. Furthermore, the media triggered positive behavioral changes, such as increased enthusiasm and active participation, proving its superiority over conventional, decontextualized instruction.

As a practical recommendation, teachers are encouraged to optimize the use of flashcards in learning activities, particularly for concepts requiring visual discrimination. Key design elements, such as contrasting colors, clear imagery, and simple information, must be maintained to ensure the media remains age-appropriate and engaging. Ultimately, this study demonstrates that integrating traditional flashcards with contextual relevance and interactive play provides a holistic strategy for enhancing foundational 21st-century skills during the "Golden Age" of child development.

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